



Hesperornis.

Pterodactyl.

Mosasaur.

Plesiosaurus.

**KANSAS CRETACEOUS SEA.**

# **PART II.**

## **CRETACEOUS FISHES.**

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### **SELACHIANS AND PYCNODONTS,**

By S. W. WILLISTON.

### **TELEOSTS,**

By ALBAN STEWART.

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**Plates XXIII to LXXIII.**

## SELACHIANS AND PYCNODONTS.

By S. W. WILLISTON.

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THE following notes and descriptions of selachian and pycnodont teeth are based upon the material that has accumulated in the University of Kansas Museum during the past ten or twelve years, supplemented by a collection kindly loaned for study by Mr. T. W. Stanton, of the National Museum. The material is by no means exhaustive, nor even sufficient to settle several doubtful points, but I trust that, incomplete as it may be, it will be of service in the determination of our numerous forms.

“The specific determination of the detached teeth of sharks and skates is little more than guesswork, and to decide upon their generic relationships with any approach to certainty is also often very difficult.”<sup>1</sup> Nevertheless, because such detached teeth are so often found, and connected series so rarely, an attempt at their determination is desirable. Fortunately, in the present collection there are several forms represented by such complete specimens that the positive addition they afford to the knowledge of the species and genera is very welcome.

### MYLIOBATIDÆ.

#### PTYCHODUS.

Teeth with the crown more or less elevated and overhanging, ornamented with transverse or radiating ridges, and surrounded by a larger or smaller, finely marked area. Surface of root smooth.

This genus of Upper Cretaceous selachians was for a long time placed among the cestracions, but recent discoveries of the nearly complete dentition render it more probable that its

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1. Woodward: Proc. Geol. Assoc., XIII, p. 190.

proper location is with the Myliobatidæ. The living members of the family, the sea-devils, are broad, flat fishes, allied to the rays, with a disk-like body. Many attain an enormous size, fifteen or twenty feet in length, and weigh a thousand pounds or more. In some the pectoral fins take on almost the character of limbs, and are said to be used in scooping up their food and transferring it to the mouth. The teeth are flat and pavement-like, and are used for crushing crabs and shell-fish. The fish are viviparous, and for the most part live in tropical or semitropical waters.

The teeth in *Ptychodus* are not less than 600 in number in each jaw, at least in some species. They are arranged in parallel rows, decreasing in size from within outward, except that in the supposedly upper jaws the median row is composed of small, low and smooth teeth, very much unlike the immediately adjacent ones. In *P. mortoni* there are eight rows on either side of this median row, or seventeen in all. The lateral teeth become more transversely elongated, the surface markings less conspicuous, and the form more unsymmetrical. About fifteen species of the genus have so far been discovered, all from the Upper Cretaceous. One or two species, including our most common one, have been discovered in both Europe and North America, and it is not improbable that the identity of yet others will be established when they are better known. The teeth vary so much in size and shape in the same individual that the identification from single specimens is often impossible or a matter of great uncertainty.

***Ptychodus mortoni*.** Plate XXV; plate XXVI, fig. 1; plate XXVII.

*Ptychodus mortoni* (Mantell) Morton, Journ. Acad. Nat. Sci. Phil., VIII, p. 215, pl. x, f. 7; Agassiz, Poiss. Foss., III, p. 158, pl. xxv, ff. 1-3; Leidy, Proc. Acad. Nat. Sci. Phil., (1868), p. 205; Ext. Vert. Fauna, p. 295, pl. xviii, ff. 1-14; Cope, Cret. Vert., p. 294; Woodward, Quart. Journ. Geol. Soc., XLIII, p. 130; Cat. Foss. Fishes Brit. Mus., I, p. 159; Proc. Geol. Assoc., XIII, p. 191, pl. v, f. 4; Williston, Kans. Univ. Quart., IX, p. 30, pl. VII, VIII, f. 1, pl. IX—Alabama, Mississippi, Niobrara of Kansas, English Chalk.

This species is the most common one of this genus in the Kansas Cretaceous, occurring only in the Niobrara beds, so far as I am aware, and, for the most part at least, in the lower part

of the beds. I have before me at the present time two excellent series of teeth of this species; one, including about eighty teeth, obtained from the estate of the late Joseph Savage; the other collected in the vicinity of Castle Rock, in Trego county, by Prof. G. E. Rose—an exceedingly interesting specimen, because most of the teeth are in place in the matrix. A number of the teeth of the Savage specimen have been arranged serially and photographed in plate XXV. Of course the arrangement is not the natural one, but the plate will show in an excellent way many of the characters of the teeth better than they can be described. In plates XXVI and XXVII are given three views of portions of the Rose specimen; that of plate XXVI (fig. 1) shows a little more than one-half of the upper view. One end (the left of the figure) has been folded underneath obliquely. This folded end is shown in plate XXVIII, fig. 1. Figure 2 of the same plate gives a view of a transverse series, as arranged from the loose teeth taken from the right end of the specimen—the one that protruded from the chalk when discovered. About 550 teeth, all told, have been obtained, and doubtless not a few had been lost before the specimen was discovered. The set is referred to the upper jaw, on the supposition of Woodward that the small median teeth belong in this jaw.

Not a trace of osseous substance is preserved in the specimen. The cartilage of the sharks' jaws is often preserved in a soft, calcified condition, but it is evident that the material in which the teeth of *Ptychodus* were lodged was of a more perishable nature, accounting doubtless for the fact that *Ptychodus* teeth are so rarely found associated.

The teeth of this species differ markedly from those of all other known species, in having the center of the crown raised into a conical apex, the summit of which is crossed by a short transverse ridge from which other diverging ridges run. In the smaller lateral teeth these ridges become less well marked and occupy a relatively smaller space, becoming almost obsolete in the fifth row. The marginal area is formed of fine reticulations in many of the larger teeth, though in most of these and in all the smaller teeth the markings are more like a fine punc-

tulation, clearly visible only with the aid of a lens, giving a uniform, finely roughened appearance. The median upper row is composed of low, flattened teeth, transversely oval or sub-square in shape, with a slight elevation in the middle, and finely roughened throughout the whole coronal surface, there being only the slightest trace of the divergent ridges on the summit of the elevation. This does not quite agree with Woodward's description of these teeth, in which he states that they are "not marked with the radiating ridges, but exhibit a minute smooth eminence in the middle of the crown." Possibly this effect is due to wear.

***Ptychodus polygyrus*.** Plate XXIX, fig. 9; plate XXX, fig. 14.

*Ptychodus polygyrus* (Buckland) Agassiz, Poiss. Foss., III, p. 156, pl. xxv, ff. 4-11, pl. xxv-B, ff. 21-23; Gibbes, Journ. Acad. Nat. Sci. Phil., I, p. 299, pl. II, ff. 5, 6; Leidy, Proc. Acad. Nat. Sci. Phil. 1868, p. 208; Cope, Cret. Vert., p. 294; Woodward, Cat. Foss. Fishes Brit. Mus., I, p. 143, pl. v, f. 7—Senonian, Turonian of Europe, Rotten Limestone of Alabama, Niobrara of Kansas; Williston, cf. cit. 31.

? *Ptychodus latissimus* Agassiz, l. c., fig. 8; Dixon, Foss. Sussex, pl. xxx, ff. 1, 2.

A single tooth of very large size from the lower beds of the Niobrara Cretaceous of the Smoky Hill river is referred to this species provisionally. Until numerous specimens are examined there can be no certainty of its correct location, though the resemblances are sufficiently great to render the determination not improbable; at least with some of its varieties.

***Ptychodus martini*.** Plate XXVIII.

*Ptychodus martini* Williston, cf. cit. 32.

A large series of teeth, 110 in number, found together in the Niobrara chalk of the Smoky Hill river, and collected by Mr. H. T. Martin, cannot be identified with any described species. I have photographed them, arranged as symmetrically as possible, but with no assurance that the arrangement is a natural one. In fact, it is not improbable that the teeth belong to both upper and lower jaws. The teeth apparently from the lower median row are much elongate transversely, with a very flat crown, wherein they differ from the teeth of other known species. The ridges are nine or ten in number, and reach nearly to the lateral

margin. In some of the teeth several of the ridges form loops near the extremities. The marginal area of granulations is small, and presents scarcely any distinct vermiculations. The teeth of the lateral rows are less elongated than those of the middle one, though still more so than is usual. The granulations become rather more extensive in area proportionally in the small teeth, as is the case with other species. A series (left vertical row of the plate) that may belong in the medio-lateral rows of the upper jaws are more nearly square in shape, and the crown has a distinct, though low, convexity extending over nearly its whole area. Antero-posteriorly the surface is nearly flat, with a moderate convexity of the margin. The surface posterior to the large grooves on the upper part shows small, radiating and branched ridges.

The largest teeth measure 45 by 20 mm.; the ones more nearly square, 35 by 25 mm.

***Ptychodus anonymus*.** Plate XXIX, figs. 5-8, 16-18, 20-22, 24.

*Ptychodus anonymus* Williston, cf. cit. 32.

Seven teeth of nearly uniform size, four of them united in the matrix, from Walnut creek, Kansas, seem to belong to a species distinct from any previously described (figs. 16-18). They are of about the same size as those described as *P. whippleyi* and *P. occidentalis*, but will be distinguished from the former by the more broadly conical crowns. In the teeth of this size of *P. whippleyi* the crown is much compressed, standing up, tooth-like; in the present specimens they are nearly straight or gently concave from the apex to the rims. From *P. occidentalis* the species will be distinguished by the very distinctly reticulate marginal areas, the transverse ridges not reaching to the rims of the crown. Other specimens agreeing in these characters are from the Niobrara. The horizon is probably Benton.

**Ptychodus occidentalis.** Plate XXIX, fig. 4; plate XXX, fig. 13.

*Ptychodus occidentalis* Leidy, Proc. Acad. Nat. Sci. Phil. 1868, p. 207; Ext. Vert. Fauna West. Terr., p. 308, pl. xvii, ff. 7, 8, pl. xviii, ff. 15-18; Cope, Cret. Vert., p. 244; Williston, cf. cit. 33—Niobrara, Benton of Kansas.

Two teeth, one from the same conglomerate that yielded the teeth referred to *P. janewayii*, the other, without locality, from Mr. Joseph Savage's collection, I refer to this species. The species differs from the following in having the transverse ridges continued to the lateral rims, and not separated by an area of fine reticulation. The anterior surface has finer, elongated, nearly straight ridges and grooves in this species, while in the others the markings are reticulate or vermiculate.

**Ptychodus janewayii.** Plate XXX, figs. 9, 10, 11.

*Sporetodus janewayii* Cope, Hayden's Bull. U. S. Geol. Surv. No. 2, (1874), pl. XLVII.

*Ptychodus janewayii* Cope, Cret. Vert., p. 244; Williston, cf. cit. 33.

"Surface irregularly convex, covered with a dense layer, which does not exhibit pores, and is thrown into transverse or oblique ridges. Surface with four folds, which traverse it obliquely from border to border. At the base of the outer, at one end, is a series of adherent tubercles; at the basis of that, at the opposite end, is a broken fold, with tubercles at its outer base. Length, 0.0045 m.; width, 0.0025 m. A portion of a larger and more central tooth has the surface with an unsymmetrical convexity, and is crossed transversely by five folds, from border to border."<sup>2</sup>

Three small teeth, shown enlarged in plate XXX, ff. 9-11, from the conglomerate containing specimens of *Corax curvatus*, appear to belong to this species. The horizon of the conglomerate is near the line of contact between the Dakota and Benton, in Ellsworth county. Cope's type was from a bed of conglomerate containing *Lamna* and *Isurus* teeth of small size near Stockton. It is probable that the horizon is the same in both.

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2. Cope, l. c.



**Ptychodus whippleyi.** Plate XXIX, figs. 10-15.

*Ptychodus whippleyi* Marcou, Geol. North Amer., p. 33, pl. ix, f. 4; Leidy, Ext. Vert. Fauna, p. 300, pl. xviii, ff. 19, 20; J. S. Newberry, Rep. Expl. Exp., p. 147, pl. iii, f. 2; Cope, Cret. Vert., p. 294; Williston, cf. cit. 34—Cretaceous, Texas (Marcou, Leidy); Kansas, Arkansas Valley (Cope); Colorado, New Mexico.

Thirteen teeth from Dallas, Tex., and a number of others received from Mr. Frank Springer, collected in the vicinity of Las Vegas, in New Mexico, agree with the descriptions and figures of this species, as given by Leidy. The same species has been referred to the Niobrara chalk of the Arkansas valley by Cope. If his determination and locality are correct the species must be referred to the Benton of Kansas, since the Niobrara does not occur in the Arkansas valley. A single specimen from the Benton of Kansas in the museum, without definite locality, seems to agree pretty well with the Texas specimens, but the specimen is an uncharacteristic one and may pertain to some other species.

Some of the teeth referred to this species show a marked resemblance to those figured by Woodward<sup>3</sup> (*P. rugosus*), and by Dixon (*P. altior* Dix.)

The European species is described as having the sides of the median elevation of the crown smooth, which is not the case with the present species, the grooves continuing midway into the lateral granulations.

**Ptychodus, sp.** Plate XXIX, figs. 2, 3; plate XXXI, fig. 53.

*Ptychodus, sp.*, Williston, cf. cit. 34.

Four teeth of moderately large size, from the Benton Cretaceous, of Salt creek, Russell county, and two others of smaller size, also from the Benton, seem to belong to a species distinct from any hitherto known. The larger ones will be distinguished from those referred to the upper series of *P. martini*, which are of nearly the same size and shape, by the smaller area of transverse ridges, and the much larger area of marginal reticulations, which are coarser. The teeth are more nearly square and the convexity of the crown is greater. The two teeth of smaller

3. Cat. Foss. Fishes Brit. Mus., I, pl. V, fig. 2.

size probably belong with the others. It is possible that some of these teeth may belong with *P. polygyrus*.

The other described species of this genus are the following :

*Ptychodus mammilaris* Agassiz.—Senonian, Turonian, and Cenomanian, Europe.

*Ptychodus rugosus* Dixon.—Senonian, England.

*Ptychodus decurrens* Agassiz.—Senonian, Turonian, and Cenomanian, Europe.

*Ptychodus multistriatus* Woodward.—Senonian and Turonian, England.

*Ptychodus latissimus* Agassiz.—Turonian and Senonian, Europe.

*Ptychodus papillosus* Cope, Cret. Vert. 294.—Upper Cretaceous, Colorado.

*Ptychodus triangularis* Reuss.—Upper Cretaceous, Bohemia.

*Ptychodus levis* Woodward.—Lower Chalk of England.

### SCYLLIIDÆ.

The family Scylliidæ comprises small sharks with sharp-pointed cuspidate teeth, arranged in numerous series. The following genera are given by Woodward :<sup>4</sup> *Paleoscyllium* Wagner, Lower Kimmeridgian of Bavaria ; *Scylliorhinus* Blainv., Turonian and Senonian ; *Pristiurus* Bonaparte, Lower Kimmeridgian of Bavaria ; *Mesiteia* Kramb., Senonian and Middle Eocene ; *Chiloscyllium* Muller and Henle, Molasse ; *Crossorhinus* Muller and Henle, Gault ; *Cantioscyllium* Woodw., Turonian ; *Ginglymostoma* Muller and Henle, Danaian, Eocene.

Numerous teeth from the Lower Cretaceous of Kansas seem in all probability to belong in this family, and agree pretty well, though rather large, with the teeth of *Scylliorhinus*, to which I refer them provisionally.

***Scylliorhinus rugosus*.** Plate XXIV, fig. 5.

*Scyllium rugosum* Williston, Kans. Univ. Quart., IX, p. 35.

Central cusp broad, pointed, nearly symmetrical, the cutting edges nearly straight, one of them a little longer than the other and slightly convex near the tip ; a single pair of lateral denticles, which are nearly equilaterally triangular in shape ; principal cusp with six or seven strong ridges on the basal two-fifths ; denticles with four or five similar ridges reaching two-thirds of

4. Cat. Foss. Fishes Brit. Mus., I, p. 338.

the way to the apex; root narrow, apparently not at all produced at the angles; thinned and not at all tumid.

Type No. 1949, U. S. National Museum, Greenleaf sandstone at Greenleaf ranch.

Height of middle cusp .....	7 mm.
Width of same at base .....	4 "
Height of denticles .....	3 "
Width of same .....	2½ "

**Scylliorhinus planidens.** Plate XXIV, fig. 7.

*Scyllium planidens* Williston, Kans. Univ. Quart., ix, p. 35.

Central cusp broad, pointed, convex from side to side, with sharp, non-crenulate edges; lateral cusps sharply pointed, smooth, two in number; root thin, narrow, moderately produced below the posterior denticle, smooth.

Height of median cusp .....	4 mm.
Width of same at base .....	3 "
Width of base of tooth .....	6 "
Height of denticles .....	1½ "

Type No. 1949, U. S. National Museum. From same horizon as the preceding species.

I refer provisionally to this species numerous other specimens from the same horizon and collection. They differ in the relative size of the denticles, the more posterior direction of the main cusp, and the size. One tooth seems to lack the anterior denticle, which is always the smaller of the two; its absence may be due to injury.

**Scylliorhinus (*Lamna?*) gracilis.** Plate XXIV, fig. 6.

*Scyllium (*Lamna?*) gracilis* Williston, Kans. Univ. Quart., ix, p. 35.

Main cusp elongate, slender; inner surface smooth, gently convex longitudinally, more so transversely, with sharp, smooth edges; the interior edge nearly straight, the posterior somewhat concave; denticles of nearly equal size, small, slender, acute; base narrow, prolonged into a slender root at each extremity.

Height of tooth .....	9 mm.
Length of middle cusp .....	6 "
Width of same at base .....	3 "
Length of denticles .....	2 "

One specimen, No. 1949, U. S. National Museum, with the preceding species.

**LAMNIDÆ.**

The Lamnidæ comprise the largest and most voracious of the sharks, represented by a number of species in the oceans of the present time. They are elongated fishes, the dorsal fin without spine; there is no nictitating membrane to the eye, and the gill openings are wide. The teeth are solid in the adult, and are 300 or more in number. The teeth are found very commonly in the Cretaceous deposits of Kansas, as elsewhere, usually scattered singly, though occasionally found more or less connected by the calcified cartilage of the jaws in several rows. Owing to the great variation of size and shape of the teeth in the same individual, it is often difficult or impossible to correctly determine the forms. Doctor Eastman has recently figured and described the nearly complete dentition of *Isurus mantelli*, the most common species of the family in Kansas. Doubtless similar variations will be found in the different species of the other genera of this family.

**ISURUS.**

This genus differs from *Lamna* only in the prevailing absence of the lateral denticles of the teeth. The teeth are large. The genus occurs from Jurassic to the present time.

*Isurus mantelli*. Plate XXXI, figs. 41-46; plate XXXII, figs. 2-2m.

*Oxyrhina mantelli* (Geinitz) Agassiz, Poiss. Foss., III, p. 282, pl. xxxiii, ff. 1-5, 7-9; Eastman, Paleontographica, xli, pp. 149-192, pls. xvi-xviii (where additional extensive synonymy will be found); Woodward, Proc. Geol. Assoc., XIII, p. 196—Cenomanian, Senonian and Turonian of Europe; Kansas, Texas, New Jersey, Alabama, Colorado, etc.

*Oxyrhina extenta* Leidy, Ext. Vert. Fauna, p. 302, pl. xviii, ff. 21-25.

“Moderate-sized, stout, three-cornered teeth; the crown on the outer side nearly flat, with one or more vertical wrinkles; on the inner side, lightly convex and smooth; root long, thick, low, moderately deeply furcate, usually obtuse at the ends, and on both sides more or less flattened.”<sup>5</sup>

This species is very common in the Kansas Niobrara, in fact,

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5. Eastman, l. c.

the most common of all, and not infrequently it is represented by many associated teeth. From the plates, and from Eastman's figures, it will be readily identified in all its forms.

#### LAMNA.

Teeth, except some of the hindmost ones, with a narrow, compressed, conical cusp, with one or two pairs of small, pointed denticles.

Some of the following species may belong to *Odontaspis*, which can hardly be distinguished by the teeth alone, differing only in the relatively less high and less subulated character of the anterior ones, and in the usually larger size of the lateral denticles.

*Lamna appendiculata*. Plate XXVI, figs. 3-3c; plate XXXI, figs. 47-49.

*Otodus appendiculatus* (Roemer) Agassiz, Poiss. Foss., III, p. 279, pl. xxxii, ff. 1-25; Davis, Trans. Roy. Dubl. Soc., IV, p. 402, pl. xli, ff. 1-11.

*Lamna appendiculata* Woodward, Cat. Foss. Fishes Brit. Mus., I, p. 393; Proc. Geol. Assoc. XIII, p. 196; Williston, cf. cit. 37—Senonian, Cenomanian, Turonian (?), Danian of Europe, Niobrara of Kansas, and Greensand of New Jersey.

“Teeth robust, with a thick root, having a much flattened postero-inferior face, the nutritive foramen not in a groove. Outer face slightly convex or flat, often with a few indefinite vertical folds on the basal half; inner side of crown markedly convex, smooth; cutting edges prominent; a single pair of lateral denticles, broad, but pointed. Anterior teeth narrow and upright; lateral teeth much inclined backward, the anterior teeth much more arcuate and longer than the posterior ones.”<sup>6</sup>

Several teeth from the Niobrara chalk agree sufficiently well with the foregoing description, and especially with Woodward's figures, to permit their allocation here. They are somewhat broader than the specimens figured by Woodward. Two of the specimens differ markedly from the others in having the base flatter and the roots much less prolonged downward, the notch of the base shallower and shorter. Another tooth from the base of the Benton, in the conglomerate containing the specimens of *Corax curvatus* and *Ptychodus janewayii*, agrees well

6. Woodward, l. c.

with these last specimens and apparently belongs to the same species, if distinct. Their resemblance to *Odontaspis kopingensis* Davis likewise cannot be denied, but the lateral denticles are more triangular in shape.

**Lamna sulcata.** Plate XXIV, figs. 1-1b.

*Otodus sulcatus* Geinitz, Char. Schicht. u. Petrifact, saechs-boehm Kreid. 5, pl. iv, f. 2.

*Otodus divaricatus* Leidy, Ext. Vert. Fauna, p. 305, vol. xviii, ff. 26-28; Cope, Cret. Vert., p. 295.

*Lamna sulcata* Woodward, Cat. Foss. Fishes Brit. Mus., i, p. 398 (where additional synonymy will be found); Proc. Geol. Assoc., xiii, p. 197; Williston, cf. cit. 37—Cenomanian and Turonian, England, France, Belgium, Saxony, Bohemia; Senonian, England; Cretaceous, Texas, (Leidy); Jewell county, Kansas, (Cope); Mississippi (Cope).

“Teeth very robust, the crown sometimes attaining a height of nearly 50 mm. Outer face of crown slightly convex, generally uneven; both the inner and the outer faces with more or less prominent series of vertical wrinkles near the base, usually irregular. A single pair of large, acuminate lateral denticles, slightly divergent, often incompletely separated from the principal cone. Root with a considerable inward prominence immediately below the base of the crown.”<sup>7</sup>

“A name given to very large, robust teeth with vertically wrinkled crown and slightly divergent acuminate lateral denticles. There are specimens in the British Museum from undetermined horizons in the chalk of Kent, Surrey, and Sussex.”<sup>8</sup>

This species is unknown to me. Its occurrence in Kansas is given on the authority of Cope. The horizon is evidently the Benton.

**Lamna mudgei.**

*Lamna mudgei* Cope, Cret. Vert., p. 207, pl. xii, ff. 11, 12; Williston, cf. cit. 38—Niobrara of Kansas, Greensand of New Jersey.

“Indicated by three teeth from the Niobrara epoch of Kansas and one from the Greensand No. 4, from New Jersey. These teeth are rather stout, especially at the base, and the crown is not very elongate. The root is excessively protuber-

7. Woodward, l. c.

8. Woodward.

ant, projecting horizontally beyond the convex side, and flat or truncate below the protuberance. The enamel is entirely smooth. Length, 14 mm."

This species is unknown to me, or unrecognizable from the description and figures of the mutilated type specimens.

***Lamna macrorhiza.***

*Lamna macrorhiza* Cope, Cret. Vert., p. 297, pl. XLII, ff. 9, 10; Woodward, Cat. Foss. Fishes, Brit. Mus., I, p. 399; Williston, cf. cit. 38—Niobrara of Kansas; Albian, of England; Cenonian, of S. E. Russia (Woodward).

"Teeth of small size, elevated though robust, the maximum total height being about 25 mm. Outer coronal face flat, or nearly so, with a faint median longitudinal elevation, and often a few folds at the base; inner coronal face very convex, smooth; cutting edges sharp; a single pair of relatively large, narrow, acuminate lateral denticles, divergent, also often marked at the base by minute vertical folds; root with a prominent inward projection below the base of the crown; nutritive foramen in a groove."

The above description by Woodward is drawn from a European specimen, while the type described and figured by Cope is from Ellis county, Kansas, probably Niobrara. I do not know the species.

***Lamna (Odontaspis?)*, sp. Plate XXX, fig. 5.**

*Lamna (Odontaspis?)*, sp., Williston, cf. cit. 38.

A single tooth from the Lower Cretaceous (Kiowa shales, Clark county), resembles the figure of *Odontaspis kopingensis* Davis, as figured by that author<sup>9</sup> except that it is smaller and has the base rather more prominent, more triangular, and more pointed. The tooth has also resemblance to *Lamna appendiculata*, but the denticles are stouter (compare Woodward.)<sup>10</sup> Height of crown, 15 mm.; width of base, 18 mm.; width of base of crown, 9 mm.; distance between points of denticles, 14 mm.

9. Trans. Roy. Dubl. Soc., IV, XXXVI, figs. 27, 28.

10. Proc. Geol. Assoc., XIII, pl. VI, fig. 26.

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***Lamna macrorhiza.***

*Lamna macrorhiza* Cope, Cret. Vert., p. 297, pl. XLII, ff. 9, 10; Woodward, Cat. Foss. Fishes, Brit. Mus., I, p. 399; Williston, cf. cit. 38—Niobrara of Kansas; Albian, of England; Cenonian, of S. E. Russia (Woodward).

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9. Trans. Roy. Dubl. Soc., IV, XXXVI, figs. 27, 28.

10. Proc. Geol. Assoc., XIII, pl. VI, fig. 26.



**Lamna**, sp. Plate XXX, fig. 6.

*Lamna*, sp., Williston, cf. cit. 39.

A somewhat injured tooth, of larger size than the last, differs in having a larger and stouter base, the inner projection in the middle of the latter stouter and broader, and the lateral denticles smaller and more obtuse. Height of tooth (approximately), 32 mm.; width of base of crown, 12 mm.; width of base of tooth, 25 mm.

One specimen, Kiowa shales, Clark county.

**Lamna quinquelateralis**.

*Lamna quinquelateralis* Cragin, Colo. Coll. Studies, v, p. 189; Williston, cf. cit. 39.

"The specific name *quinquelateralis* is applied to a species of shark whose vertebræ differ from all others of which I have any knowledge. The type vertebra is short, much broader than high, shallow-cupped, and more or less sharply pentagonal ended.

"Measurements: Height, 20 mm.; length, 12 mm.; breadth, 12 mm. The two upper angles measure each about 130 deg.; either lateral angles about 105 deg.; the lower angle is broad and rounded.

"Occurrence: A single vertebra of this form was found by the writer at Belvidere, Kan., with the above-described remains of *Plesiochelys*, in the upper part of No. 4 of the Belvidere section."

Possibly this vertebra belongs with one or the other of the above-described teeth from these same deposits, but the correlation cannot be made until the teeth and vertebræ are found associated, which may be long hence.

**Scapanorhynchus**.

*Rhinognathus* Davis, Trans. Roy. Dubl. Soc. (2), III, p. 480.

*Scapanorhynchus* Woodward, Cat. Foss. Fishes Brit. Mus., I, p. 351, (1889).

? *Mitsukurina* Jordan, Proc. Calif. Acad. Sci. Zool., I, (1898); Amer. Nat., xxxiv, p. 234.

The genus *Scapanorhynchus*, first proposed by Davis under a preoccupied name, has been more closely defined by Woodward. The teeth themselves cannot in many cases be generically dis-

tinguished from those of *Odontaspis*, under which name some were originally described.

Recently Doctor Woodward<sup>11</sup> has identified a modern genus of sharks, from the deep sea off Yokahama, Japan, with this supposedly extinct type—*Mitsukurina* Jordan.

Possibly the positive identification is premature, but there seems to be no doubt of the close relationship of the two forms, at least.

**Scapanorhynchus raphiodon.** Plate XXVI, fig. 4; plate XXXII, fig. 5.

*Lamna* (*Odontaspis*) *raphiodon* Agassiz, Poiss. Foss., III, p. 296, pl. XXXVII-A, ff. 12-16.

*Scapanorhynchus raphiodon* Woodward, Cat. Foss. Fishes Brit. Mus., I, p. 353 (where additional synonymy will be found); Proc. Geol. Assoc. XIII, p. 196—Cenomanian, Russia and Galicia; Cenomanian and Turonian, France, Saxony, and Bohemia; Cenomanian-Senonian, England; Upper Cretaceous, S. India; Upper Cretaceous of Texas, Mississippi, New Jersey; Benton Cretaceous of Kansas.

*Lamna texana* Roemer, Kreideb. von Texas, p. 29, pl. I, ff. 7; Leidy, Rep. U. S. Geol. Surv., I, p. 304, pl. XVIII, ff. 46-50; Cope, Cret. Vert., p. 296.

Teeth of considerable size, slender, the anterior ones without lateral denticles; inner coronal face conspicuously and finely striate.

A number of teeth before me from the Cretaceous of New Jersey and one from the Benton Cretaceous of Kansas agree fairly well with the figures given by Leidy of specimens from Mississippi, New Jersey, and "from near the mouth of Vermilion creek, in Kansas," and which agree with those from Texas called *Lamna texana* by Roemer.

The specimens agree so well with the European species, especially as figured by Woodward (l. c.; I have no European specimens for comparison), that I think there cannot be much doubt of their identity, a conclusion suggested by Woodward.

The Kansas specimen described by Leidy was said to have been obtained by Hayden from a "gray sandstone from near the mouth of Vermilion river." The Vermilion in Kansas runs its whole length through the Carboniferous in eastern Kansas; nor do I think there is any gray sandstone (necessarily Dakota Cretaceous) in the state which will yield these teeth. In all

11. Amer. Mag. Nat. Hist., III, p. 487 (1899).

probability the specimens did not come from this state. However, a specimen in our collection agreeing with the species was obtained in the state, and probably from the Benton, though possibly from either the Niobrara or Fort Pierre.

#### CORAX.

The genus *Corax* is confined wholly to the Cretaceous, and is yet incompletely known. Its distinction from *Galeocerdo*, under which name some of its species have been described, is based upon the solidity of the teeth—those of *Galeocerdo* have a hollow cavity within. The teeth are small, compressed, more or less triangular, with marginal serrations, though this character may be more or less wanting in young individuals. They vary not a little in shape in the same individual. In some the crown is nearly bilaterally symmetrical, but they more usually have the crown directed more or less obliquely backward, the anterior margin convex, the posterior more or less straight and angulated.

Three species of the genus are known in England—*C. falcatus*, *C. pristodontus*, which is hardly distinct, and *C. affinis*. In addition, *C. antiquus* Desl., *C. incisus* Egert., *C. lævis* Gieb. and *C. pygmæus* Munst. have been described from Europe, and *C. crassidens* Cope and *C. hartvelli* Cope from the United States.

**Corax falcatus.** Plate XXXI, figs. 1-40; plate XXXII, figs. 1-11.

*Corax falcatus* Agassiz, Poiss. Foss., III, p. 226, pl. xxvi, f. 14, xxvi-A, ff. 1-15; Woodward, Cat. Foss. Fishes Brit. Mus., I, p. 424 (where additional synonymy will be found); Proc. Geol. Assoc., XIII, p. 198, pl. vi, ff. 13-15—Cenomanian and Turonian of England, France, Switzerland, Saxony, Bohemia, Galicia, and Russia; Senonian of England and France; Cretaceous of Texas, New Jersey, and Mississippi; Niobrara of Kansas.

*Galeocerdo falcatus* Leidy, Ext. Vert. Fauna West. Terr., p. 301, pl. xvii, ff. 29-42.

The very variable shape of the teeth referred to this species will be seen in plate XXXI, figs. 1-40. Possibly the specimens there figured represent distinct species. *C. (Galeocerdo) crassidens* Cope seems to be represented by fig. 24, and *C. (Galeocerdo) hartvelli* Cope<sup>12</sup> by fig. 23. Possibly this species also includes

12. Cret. Vert., p. 244.

*C. pristodontus* and *C. lindstromi*, both of which seem to be imperfectly differentiated from *C. falcatus* at present.

In plate XXXIII, figs. 1-11, are shown a number of teeth pertaining to a single individual and found associated with many others, by Mr. Martin, in the Niobrara Cretaceous of the Smoky Hill valley. Isolated teeth of this species are the most abundant of the selachian teeth in the Niobrara of Kansas. Only in very few instances have many teeth been found associated, so that it is yet impossible to fully understand the dentition. The species occurs rarely, if at all, in the lower Niobrara horizons, where those of *Isurus* and *Ptychodus* are the most abundant.

***Corax curvatus*, n. sp.** Plate XXX, figs. 7, 8.

Two specimens from the same block which yielded those of *Ptychodus janewayii* and *Lamna* species, *antea*, seem evidently specifically distinct from the foregoing. These teeth, while not differing much in outline from certain ones referred to *C. falcatus*, show a marked variance in structure. In *C. falcatus* the outer surface of the tooth stands out but very slightly. In *C. curvatus* the crown is attached to the root very obliquely, so that when resting upon a plane the tooth forms a high arch, touching only by the extreme tips of the roots and crown. The inner surface, also, is very much more uneven and convex, the crown separated from the root by a marked, narrow, transverse ridge, which is scarcely indicated in the teeth of *C. falcatus*. Altitude, 8 mm.; greatest width, 14 mm.; horizon, lower or lowermost Benton of Ellsworth county.

#### LEPTOSTYRAX.

Williston, Kans. Univ. Quart., IX, p. 42, 1900.

***Leptostyrax bicuspidatus*.** Plate XXIV, figs. 15, 15a; plate XXVI, fig. 7.

*Leptostyrax bicuspidatus* Williston, cf. cit. 42.

Principal cusp long and slender, flattened upon the outer side, with sharp, smooth edges and a median convexity in the middle of the flattened surface; for the most part convex longitudinally, gently concave before the apex. Inner surface strongly convex from side to side, concave on the lower half

longitudinally, gently convex on the upper part. A single denticle present, slender, flattened cylindrical, with an anterior and posterior carina; it arises below the base of the main cusp, and is directed more outwards, its inner surface concave longitudinally. Immediate base of crown of both main cusp and denticle with short ridges. Base of tooth short, truncate (?) below the main cusp, prolonged downward below the denticle. Length of main cusp, 19 mm.; width of same at base, 5 mm.; length of denticle, 5 mm.; width of same at base,  $2\frac{1}{2}$  mm.; height of tooth, 26 mm.; width of base, 10 mm.

A small tooth of the same form found with this has a total length of 14 mm. The base is deeply emarginate below, with two slender roots; that below the denticle the longer. Mentor beds,  $4\frac{1}{2}$  miles southwest of Marquette, Kan.

U. S. Nat. Mus. No. 1979.

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### PYCNODONTIDÆ.

The pycnodonts are a peculiar group of ganoid fishes, whose remains have been found in the Jurassic, Cretaceous and Eocene deposits of Europe, North America, Asia, and Australia. They are all rather small fishes, very much flattened and oval in shape, covered with rhomboidal scutes having close-lying spines, which give a ribbed appearance. The united palatine and vomer of the upper jaws are provided with five rows of round or oval, smooth-pavement teeth; the premaxillary with two or four chisel-like teeth. The dentaries below have a like number of teeth, similar to those of the premaxillary, while on the splenial there are three, four or five rows of pavement teeth similar to those of the vomer.

*Cœlodus brownii*. Plate XXIV, fig. 12.

*Cœlodus brownii* Cope, Journ. Acad. Nat. Sci. Phil., ix, p. 447, pl. xx, f. 19; Williston, cf. cit. 28.

A fragment of the left lower jaw, containing two rows of teeth, the middle and the inner. There are four crowns preserved on the inner row, nearly corresponding in length with

the six teeth of the middle row, of which only two have the crowns preserved. Cope's type had only the middle and external rows, and none of the teeth had well-preserved crowns. The middle teeth seem to correspond exactly in size with the types.

On the inner side the jaw projects as a rather broad trough, with a thin edge, apparently broader posteriorly than anteriorly. Its width here is nearly as great as the width of the inner row of teeth. The inner teeth are large, their width equal to nearly half their length. The surface of the crowns is smooth and convex, more so antero-posteriorly than transversely. The middle row has the teeth placed a little obliquely to the others, and the surface is more flattened transversely in the middle. The axes of the crowns of the two rows are placed at a distinct angle with each other.

Length of four teeth, inner row .....	36 mm.
Transverse diameter of crowns, inner row .....	17 "
Length of five teeth, middle row .....	31 "
Transverse diameter of crowns, middle row .....	12 "
Thickness of jaw, at middle row of teeth .....	22 "

The specimen was collected from the Kiowa shales, near Belvidere, by Mr. C. N. Gould.

*Cœlodus stantoni*, n. sp. Plate XXIV, fig. 12; plate XXVI, fig. 6.

*Cœlodus stantoni* Williston, cf. cit. 28.

A fragment of the right lower jaw, containing two perfect crowns of the internal row, together with the bases of four teeth of the middle row, evidently represents a species distinct from the previous one. The teeth are much smaller in size, more elongated and distinctly kidney-shaped, the ends narrowed. The surface is smooth, strongly convex antero-posteriorly, and gently so from side to side. The jaw is much less robust than in the preceding species.

Transverse diameter of tooth, internal row .....	14 mm.
Antero-posterior diameter of same .....	5½ "
Length of four teeth, middle row .....	17 "
Transverse diameter of tooth, middle row .....	11 "

The middle teeth seem to be larger in proportion to those of the internal series than in the preceding species. Kiowa shales.

**Mesodon abrasus.**

*Mesodon abrasus* Cragin, Colorado College Studies, v, 1894; Williston, Kans. Univ. Quart., ix, p. 29.

“This name is proposed for certain pycnodont teeth of low, rhomboidal form and feebly convex upper surface which occur in No. 3 of the Belvidere section, southwest of the Belvidere railroad station, and seem to agree with the large mandibular teeth of *Mesodon*. The specific name refers to the occurrence in the type species of two small, oblique facets produced at one end by attrition. The type has a height (above root) of 3 mm., a length of 13 mm., and a breadth of 5 mm.

“To the vomerine set of the same species may belong the rotund, oval or nearly hemispherical teeth of similar height but smaller size, which occur not uncommonly at the same locality and horizon, the largest now available example of which measures about 6 and 7 mm. in major and minor horizontal diameters.”

In the National Museum collection there are several teeth, occurring singly, corresponding to the vomerine teeth described by Cragin. That they belong with the other teeth there described is very doubtful—indeed it is doubtful whether the other teeth belong with *Mesodon*, since it is impossible to locate the genus from single teeth. It is not at all impossible that the vomerine teeth are identical with Cope's *M. diastematicus*. The larger teeth may be the same as those of either the above-described species of *Ceolodus*.

The largest of the specimens in the present collection measures 10 by  $7\frac{1}{2}$  mm.; several smaller examples have diameters of 6 and 5 mm. (See plate XXX, fig. 4.)

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**LEPIDOSTEIDÆ.****Lepidotus, sp.**

In the National Museum collection there is a single example of a scute pertaining to some lepidotid fish (No. 1063, Kiowa shales). Cope has described *Macrepistius* of this family from a stratum between the Upper and Lower Trinity Sands of Texas. It seems very probable that the teeth referred to the vomer of *Mesodon abrasus* really belong here.